CLAIMS

WE CLAIM:

1. An EUV light source comprising:

a pulsed laser providing laser pulses at a selected pulse repetition rate focused at a desired target ignition site;

a target formation system providing discrete targets at a selected interval coordinated with the laser pulse repetition rate;

a target steering system intermediate the target formation system and the desired target ignition site;

a target tracking system providing information about the movement of target between the target formation system and the target steering system, enabling the target steering system to direct the target to the desired target ignition site.

2. The apparatus of claim 1 further comprising:

the target tracking system providing information enabling the creation of a laser firing control signal.

3. The apparatus of claim 1 further comprising:

the target tracking system comprising:

a droplet detector comprising a collimated light source directed to intersect a point on a projected delivery path of the target, having a respective oppositely disposed light detector detecting the passage of the target through the respective point.

4. The apparatus of claim 2 further comprising:

the target tracking system comprising:

a droplet detector comprising a collimated light source directed to intersect a point on a projected delivery path of the target, having a respective oppositely disposed light detector detecting the passage of the target through the respective point.

5. The apparatus of claim 1 further comprising:

the target tracking system comprising:

a droplet detector comprising a collimated light source and a detector comprising a linear array of a plurality of photo-sensitive elements aligned to a coordinate axis, the light from the light source intersecting a projected delivery path of the target.

6. The apparatus of claim 2 further comprising:

the target tracking system comprising:

a droplet detector comprising a collimated light source and a detector comprising a linear array of a plurality of photo-sensitive elements aligned to a coordinate axis, the light from the light source intersecting a projected delivery path of the target.

7. The apparatus of claim 3 further comprising:

at least one of the droplet detectors comprises a plane-intercept detection device.

8. The apparatus of claim 4 further comprising:

at least one of the droplet detectors comprises a plane-intercept detection device.

9. The apparatus of claim 5 further comprising:

at least one of the droplet detectors comprises a plane-intercept detection device.

10. The apparatus of claim 6 further comprising:

at least one of the droplet detectors comprises a plane-intercept detection device.

11. The apparatus of claim 3 further comprising:

the droplet detectors comprise a plurality of droplet detectors each operating at a different light frequency.

12. The apparatus of claim 4 further comprising:

the droplet detector comprises a plurality of droplet detectors each operating at a different light frequency.

13. The apparatus of claim 1, further comprising:

the target tracking system comprising:

a droplet detector comprising a camera having a field of view and a two dimensional array of pixels imaging the field of view.

14. The apparatus of claim 2, further comprising:

the target tracking system comprising:

a droplet detector comprising a camera having a field of view and a two dimensional array of pixels imaging the field of view.

15. A laser produced plasma EUV source comprising:

an electrostatic plasma containment apparatus providing an electric plasma confinement field at or near a target ignition site at the time of ignition.

16. The apparatus of claim 15 further comprising:

a target tracking system providing a signal enabling control of the electrostatic plasma containment apparatus.

17. An EUV light source comprising:

a vessel;

an EUV producing plasma generator;

a collector focusing produced EUV light to an intermediate focus at one end of the vessel;

an intermediate wall within the vessel between the plasma generator and the intermediate focus, the intermediate wall having an EUV light passage therein and separating the vessel into a zone of a first pressure and a zone of a second pressure;

the EUV opening having therein a low pressure trap comprising passages for focused EUV light and constructed to maintain the pressure drop across the low pressure trap due to the difference between the first pressure and the second pressure.

18. The apparatus of claim 17 further comprising:

the low pressure trap comprises a section of a solid sphere having focused fine light passages formed therein.

19. An EUV light source having a discrete target formation system providing targets at regular intervals, comprising:

a first target tracking system providing outputs indicative of the tracking of a target from the target formation system, the target tracking system outputs comprising a target position and trajectory;

a target steering system;

a feedback and control system utilizing target position and trajectory outputs to provide inputs to the target steering system to enable the target steering system to steer the target to a desired target ignition site.

20. The apparatus of claim 19 further comprising:

a second target tracking system providing outputs indicative of the tracking of a target from the target steering system;

the feedback and control system utilizing the outputs of the second target tracking system to generate a laser firing control signal.

21. The apparatus of claim 19 further comprising:

the target steering system comprises a target aiming mechanism and a target acceleration mechanism.

22. The apparatus of claim 20 further comprising:

the target steering system comprises a target aiming mechanism and a target acceleration mechanism.

23. The apparatus of claim 19 further comprising:

the first and second target tracking systems comprising an x and a y axis position detector and a z plane passage detector respectively intermediate the target delivery system and the target steering system and the target steering system and the desired target ignition site.

24. The apparatus of claim 20 further comprising:

the first and second target tracking systems comprising an x and a y axis position detector and a z plane passage detector respectively intermediate the target delivery system and the target steering system and the target steering system and the desired target ignition site.

25. The apparatus of claim 21 further comprising:

the first and second target tracking systems comprising an x and a y axis position detector and a z plane passage detector respectively intermediate the target delivery system and the target steering system and the target steering system and the desired target ignition site.

26. An EUV light source comprising a moving target plasma source and a pulsed laser plasma beam formation mechanism, wherein the respective target and the pulsed laser beam intersect at a desired target ignition site with an accuracy of about ± 10 μm, to create a plasma comprising:

a magnetic plasma confinement mechanism creating a magnetic field in the vicinity of the target ignition site to confine the plasma to the target ignition site.

27. An EUV light source comprising a moving target plasma source and a pulsed laser plasma beam formation mechanism, wherein the respective target and the pulsed laser beam must intersect at a desired target ignition site with an accuracy of about ±10 μm, to create a plasma, comprising:

a pulsed magnetic plasma containment mechanism creating a magnetic field in the vicinity of the target ignition site substantially coinciding with the existence of the plasma to contain the plasma to the target ignition site during the existence of the plasma.

28. The apparatus of claim 26 further comprising:

a target tracking system providing information enabling the control of the magnetic plasma confinement mechanism.

29. The apparatus of claim 27 further comprising:

a target tracking system providing information enabling the control of the magnetic plasma confinement mechanism.

30. An EUV light source comprising:

a pulsed laser means for providing laser pulses at a selected pulse repetition rate focused at a desired target ignition site;

a target formation means for forming discrete targets at a selected interval coordinated with the laser pulse repetition rate;

a target steering means intermediate the target formation means and the desired target ignition site;

a target tracking means for providing information about the movement of target between the target formation means and the target steering means, and for enabling the target steering means to direct the target to the desired target ignition site.

31. The apparatus of claim 30 further comprising:

the target tracking means including means for providing information enabling the creation of a laser firing control signal.

32. The apparatus of claim 30 further comprising:

the target tracking means comprising:

a droplet detector comprising a collimated light source directed to intersect a point on a projected delivery path of the target, having a respective oppositely disposed light detector detecting the passage of the target through the respective point.

33. The apparatus of claim 31 further comprising:

the target tracking means comprising:

a droplet detector comprising a collimated light source directed to intersect a point on a projected delivery path of the target, having a respective oppositely disposed light detector detecting the passage of the target through the respective point.

34. The apparatus of claim 30 further comprising:

the target tracking means comprising:

a droplet detector comprising a collimated light source and a detector comprising a linear array of a plurality of photo-sensitive elements aligned to a coordinate axis, the light from the light source intersecting a projected delivery path of the target.

35. The apparatus of claim 31 further comprising:

the target tracking means comprising:

a droplet detector comprising a collimated light source and a detector comprising a linear array of a plurality of photo-sensitive elements aligned to a coordinate axis, the light from the light source intersecting a projected delivery path of the target.

36. The apparatus of claim 32 further comprising:

at least one of the droplet detectors comprises a plane-intercept detection device.

37. The apparatus of claim 33 further comprising:

at least one of the droplet detectors comprises a plane-intercept detection device.

38. The apparatus of claim 34 further comprising:

at least one of the droplet detectors comprises a plane-intercept detection device.

39. The apparatus of claim 35 further comprising:

at least one of the droplet detectors comprises a plane-intercept detection device.

40. The apparatus of claim 32 further comprising:

the droplet detectors comprise a plurality of droplet detectors each operating at a different light frequency.

41. The apparatus of claim 33 further comprising:

the droplet detector comprises a plurality of droplet detectors each operating at a different light frequency.

42. The apparatus of claim 30, further comprising:

the target tracking means comprising:

a droplet detector comprising a camera having a field of view and a two dimensional array of pixels imaging the field of view.

43. The apparatus of claim 31, further comprising:

the target tracking means comprising:

a droplet detector comprising a camera having a field of view and a two dimensional array of pixels imaging the field of view.

44. A laser produced plasma EUV source comprising:

an electrostatic plasma containment apparatus providing an electric plasma confinement field at or near a target ignition site at the time of ignition.

45. The apparatus of claim 44 further comprising:

a target tracking means including a means for providing a signal enabling control of the electrostatic plasma containment apparatus.

46. An EUV light source comprising:

a vessel;

an EUV producing plasma generating means;

a collector focusing produced EUV light to an intermediate focus at one end of the vessel;

an intermediate wall within the vessel between the plasma generator and the intermediate focus, the intermediate wall having an EUV light passage therein and separating the vessel into a zone of a first pressure and a zone of a second pressure;

the EUV opening having therein a low pressure trap means comprising passages for focused EUV light and means for maintaining the pressure drop across the low pressure trap due to the difference between the first pressure and the second pressure.

47. The apparatus of claim 46 further comprising:

the low pressure trap means comprises a section of a solid sphere having focused fine light passages formed therein.

48. An EUV light source having a discrete target formation means for forming targets at regular intervals, comprising:

a first target tracking means for providing outputs indicative of the tracking of a target from the target formation means, the target tracking means outputs comprising a target position and trajectory;

a target steering means;

a feedback and control means for utilizing target position and trajectory outputs to provide inputs to the target steering means to enable the target steering means to steer the target to a desired target ignition site.

49. The apparatus of claim 48 further comprising:

a second target tracking means providing outputs indicative of the tracking of a target from the target steering system;

the feedback and control means utilizing the outputs of the second target tracking system for generating a laser firing control signal.

50. The apparatus of claim 48 further comprising:

the target steering means comprises a target aiming means and a target acceleration means.

51. The apparatus of claim 49 further comprising:

the target steering means comprises a target aiming means and a target acceleration means.

52. The apparatus of claim 48 further comprising:

the first and second target tracking means comprising an x and a y axis position detector and a z plane passage detector respectively intermediate the target delivery system and the target steering mechanism and the target steering mechanism and the desired target ignition site.

53. The apparatus of claim 49 further comprising:

the first and second target tracking means comprising an x and a y axis position detector and a z plane passage detector respectively intermediate the target

delivery system and the target steering mechanism and the target steering mechanism and the desired target ignition site.

54. The apparatus of claim 50 further comprising:

the first and second target tracking means comprising an x and a y axis position detector and a z plane passage detector respectively intermediate the target delivery system and the target steering mechanism and the target steering mechanism and the desired target ignition site.

55. An EUV light source comprising a moving target plasma source and a pulsed laser plasma beam formation mechanism, wherein the respective target and the pulsed laser beam intersect at a desired target ignition site with an accuracy of about ±10 μm, to create a plasma comprising:

a magnetic plasma confinement means for creating a magnetic field in the vicinity of the target ignition site to confine the plasma to the target ignition site.

56. An EUV light source comprising a moving target plasma source and a pulsed laser plasma beam formation mechanism, wherein the respective target and the pulsed laser beam must intersect at a desired target ignition site with an accuracy of about ±10 μm, to create a plasma, comprising:

a pulsed magnetic plasma containment means for creating a magnetic field in the vicinity of the target ignition site substantially coinciding with the existence of the plasma to contain the plasma to the target ignition site during the existence of the plasma.

57. The apparatus of claim 55 further comprising:

a target tracking system providing information enabling the control of the magnetic plasma confinement mechanism.

58. The apparatus of claim 56 further comprising:

a target tracking system providing information enabling the control of the magnetic plasma confinement mechanism.

59. An EUV light producing method comprising:

utilizing a pulsed laser, providing laser pulses at a selected pulse repetition rate focused at a desired target ignition site;

forming discrete targets at a selected interval coordinated with the laser pulse repetition rate;

utilizing a target steering system intermediate the formation of the target and the desired target ignition site;

utilizing a target tracking system providing information about the movement of target between the target formation and the target steering system, and for enabling the target steering system to direct the target to the desired target ignition site.

60. The method of claim 59 further comprising:

utilizing the target tracking system, providing information enabling the creation of a laser firing control signal.

61. The method of claim 59 further comprising:

the target tracking system comprising:

a droplet detector comprising a collimated light source directed to intersect a point on a projected delivery path of the target, having a respective oppositely disposed light detector detecting the passage of the target through the respective point.

62. The method of claim 60 further comprising:

the target tracking system comprising:

a droplet detector comprising a collimated light source directed to intersect a point on a projected delivery path of the target, having a respective

oppositely disposed light detector detecting the passage of the target through the respective point.

63. The method of claim 59 further comprising:

the target tracking system comprising:

a droplet detector comprising a collimated light source and a detector comprising a linear array of a plurality of photo-sensitive elements aligned to a coordinate axis, the light from the light source intersecting a projected delivery path of the target.

64. The method of claim 60 further comprising:

the target tracking system comprising:

a droplet detector comprising a collimated light source and a detector comprising a linear array of a plurality of photo-sensitive elements aligned to a coordinate axis, the light from the light source intersecting a projected delivery path of the target.

65. The method of claim 61 further comprising:

at least one of the droplet detectors comprises a plane-intercept detection device.

66. The method of claim 62 further comprising:

at least one of the droplet detectors comprises a plane-intercept detection device.

67. The method of claim 63 further comprising:

at least one of the droplet detectors comprises a plane-intercept detection device.

68. The method of claim 64 further comprising:

at least one of the droplet detectors comprises a plane-intercept detection device.

69. The method of claim 61 further comprising:

the droplet detectors comprise a plurality of droplet detectors each operating at a different light frequency.

70. The method of claim 62 further comprising:

the droplet detector comprises a plurality of droplet detectors each operating at a different light frequency.

71. The method of claim 59, further comprising:

the target tracking system comprising:

a droplet detector comprising a camera having a field of view and a two dimensional array of pixels imaging the field of view.

72. The method of claim 60, further comprising:

the target tracking system comprising:

a droplet detector comprising a camera having a field of view and a two dimensional array of pixels imaging the field of view.

73. A laser produced plasma EUV light producing method comprising:

utilizing an electrostatic plasma containment apparatus, providing an electric plasma confinement field at or near a target ignition site at the time of ignition.

74. The method of claim 73 further comprising:

utilizing a target tracking system, providing a signal enabling control of the electrostatic plasma containment apparatus.

75. An EUV light producing method comprising:

utilizing a plasma producing vessel having an intermediate wall within the vessel between having an EUV light passage therein and separating the vessel into a zone of a first pressure and a zone of a second pressure;

providing in the wall a low pressure trap comprising passages for focused EUV light and maintaining the pressure drop across the low pressure trap due to the difference between the first pressure and the second pressure.

76. The method of claim 75 further comprising:

the low pressure trap comprises a section of a solid sphere having focused fine light passages formed therein.

77. An EUV light producing means utilizing a discrete target formation system forming targets at regular intervals, comprising:

utilizing a first target tracking system, providing outputs indicative of the tracking of a target from the target formation system, the target tracking system outputs comprising a target position and trajectory;

utilizing a target steering system;

utilizing a feedback and control system, utilizing the target position and trajectory outputs to provide inputs to the target steering system to enable the target steering system to steer the target to a desired target ignition site.

78. The method of claim 77 further comprising:

utilizing a second target tracking system, providing outputs indicative of the tracking of a target from the target steering system;

utilizing the feedback and control system, utilizing the outputs of the second target tracking system for generating a laser firing control signal.

79. The method of claim 77 further comprising:

the target steering system comprises a target aiming mechanism and a target acceleration mechanism.

80. The method of claim 78 further comprising:

the target steering system comprises a target aiming means and a target acceleration means.

81. The method of claim 77 further comprising:

the first and second target tracking systems comprising an x and a y axis position detector and a z plane passage detector respectively intermediate the target delivery system and the target steering mechanism and the target steering mechanism and the desired target ignition site.

82. The method of claim 78 further comprising:

the first and second target tracking systems comprising an x and a y axis position detector and a z plane passage detector respectively intermediate the target delivery system and the target steering mechanism and the target steering mechanism and the desired target ignition site.

83. The apparatus of claim 79 further comprising:

the first and second target tracking systems comprising an x and a y axis position detector and a z plane passage detector respectively intermediate the target delivery system and the target steering mechanism and the target steering mechanism and the desired target ignition site.

84. An EUV light producing method comprising using a moving target plasma source and a pulsed laser plasma beam formation mechanism, wherein the respective target and the pulsed laser beam intersect at a desired target ignition site with an accuracy of about ±10 μm, to create a plasma comprising:

utilizing a magnetic plasma confinement mechanism, creating a magnetic field in the vicinity of the target ignition site to confine the plasma to the target ignition site.

85. An EUV light producing method comprising using a moving target plasma source and a pulsed laser plasma beam formation mechanism, wherein the respective target and the pulsed laser beam must intersect at a desired target ignition site with an accuracy of about ±10 μm, to create a plasma, comprising:

utilizing a pulsed magnetic plasma containment mechanism, creating a magnetic field in the vicinity of the target ignition site substantially coinciding with the existence of the plasma to contain the plasma to the target ignition site during the existence of the plasma.

86. The method of claim 84 further comprising:

utilizing a target tracking system, providing information enabling the control of the magnetic plasma confinement mechanism.

87. The apparatus of claim 85 further comprising:

utilizing a target tracking system providing information enabling the control of the magnetic plasma confinement mechanism.

88. An LPP EUV light source comprising:

a collector mirror comprising a multi-layer reflecting surface;

at least one component in closed enough proximity to the plasma produced in the LPP EUV light source to be eroded by the effects of the plasma;

a coating on the at least one component that is not damaging to the multi-layer reflecting surface if sputtered onto the multi-layer reflective surface.

89. The apparatus of claim 88 further comprising:

the multi-layer reflecting surface is coated with the same coating as the at least one component.

90. The apparatus of claim 88 further comprising:

the multi-layer reflecting surface includes layers of the same material as the coating of the at least one component.

91. An LPP EUV light source comprising:

an LPP EUV chamber;

a driving laser producing a driving laser beam directed at a target to produce within the chamber the plasma for the LPP EUV light source;

an input window through which the driving laser beam enters the chamber;

a heater element heating the input window.

92. An LPP EUV light source comprising:

a target formation system comprising a nozzle from which a target droplet or a liquid stream that eventually forms a target droplet is ejected along a target formation axis;

a target tracking system detecting the position of the target droplet at one or more positions in the target flight path intermediate the nozzle and the vicinity of a a desired target ignition site coordinated with the arrival of an irradiating beam at the desired target ignition site and detecting an error in that flight path and/or an error in the position of the target droplet vis-à-vis the desired target ignition site at the arrival time of the irradiating beam;

a target formation system tilting mechanism tilting the target formation axis based upon the detected error to decrease the error in a subsequent target droplet position vis-à-vis the desired target ignition site at the arrival time of the irradiating beam.